

Fishery Data Series No. 91-52

Northern Southeast Alaska Dolly Varden Research and Creel Surveys in Haines, Alaska 1989-1990

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Randolph P. Ericksen

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Robert P. Marshall

October 1991

Alaska Department of Fish and Game

Division of Sport Fish



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TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	ii
LIST OF FIGURES	iii
LIST OF APPENDICES	iv
ABSTRACT	1
INTRODUCTION	2
METHODS	5
Estimation of Abundance	5
Creel Survey	7
Contribution Estimates	9
Migrations	10
Age, Weight, and Length	10
RESULTS	10
Estimation of Abundance	10
Creel Survey	13
Contribution Estimates	17
Migrations	17
Age, Weight, and Length	21
DISCUSSION	23
ACKNOWLEDGMENTS	28
LITERATURE CITED	29
APPENDIX A	32

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Estimated harvest of Dolly Varden and effort in angler days in the Haines/Skagway and Sitka areas, 1978-1989	3
2. Results of chi-square tests to determine size categories for stratifying the mark-recapture experiment	16
3. Observed angler effort (hours), number of interviews, number of periods sampled, number of possible sampling periods, and observed harvest and catch of Dolly Varden by site and sampling period, for anglers completing their fishing trips, 1990	18
4. Estimated total effort, catch, and harvest of Dolly Varden, with estimates of precision, for the Haines roadside by sampling period, March 26 through April 29, 1990	19
5. Sampling parameters and estimated contributions of Dolly Varden ≥ 350 mm FL emigrating from Chilkat Lake between March 29 and May 20, 1990 to selected sport fisheries near Haines	20
6. Goodness-of-fit tests (H_0) comparing actual and expected numbers of (fall 1989) tagged Dolly Varden captured at the weir in 1990 and then recaptured in sport and commercial fisheries in Southeast Alaska	26

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Map showing roadside fishing areas around Chilkat Lake and Haines, northern Southeast Alaska	4
2. Map showing location of sampling sites and weir at Chilkat Lake, northern Southeast Alaska	6
3. Graph showing length frequency of Dolly Varden captured at Chilkat Lake in fall 1989 and of sample of emigrant Dolly Varden captured at the lake outlet during spring 1990	11
4. Daily catch per beach seine set during the fall 1990 sampling event	12
5. Daily count of Dolly Varden, by size group, through the Chilkat Lake outlet weir, and the daily water temperature during second sampling event	14
6. The cumulative distribution function of lengths of Dolly Varden marked in Chilkat Lake versus lengths of emigrant Dolly Varden recaptured and versus lengths of emigrant Dolly Varden examined for marks	15
7. Mean length at age for Dolly Varden sampled at the Chilkat River weir and from selected sport fisheries in 1990	22
8. Scatterplot of the growth of 1,126 Dolly Varden tagged in fall 1989 and recaptured in spring 1990, after an average 201 (range 161-223) days at large	24
9. Length frequency of Dolly Varden sampled during creel surveys at Chilkat Lake during June and July 1989 and 1990	27

LIST OF APPENDICES

<u>Appendix</u>	<u>Page</u>
A1. Release and recovery information for Dolly Varden tagged in Chilkat Lake during fall 1989 and at Chilkat Lake outlet weir during spring 1990, and recovered sport and commercial fisheries, sorted by tagging event (year) and recovery date	33
A2. Number aged, mean fork length, and mean weight of Dolly Varden mortalities sampled at Chilkat Lake outlet weir, by age and sex, April 15 through May 20, 1990	37
A3. Number aged, mean fork length, and mean weight of Dolly Varden sampled from harvests in the fishery for Dolly Varden along the Chilkat River, by age and sex, March 26 through April 29, 1990 . .	38
A4. Number aged, mean fork length, and mean weight of Dolly Varden sampled from harvests in the fishery for cutthroat trout on Chilkat Lake, by age and sex, May 21 through October 7, 1990	39
A5. Number aged, mean fork length, and mean weight of Dolly Varden sampled in harvests from the fishery for Dolly Varden and other species on the Chilkoot River, by age and sex, June 25 through November 4, 1990	40

ABSTRACT

A large recreational fishery for Dolly Varden *Salvelinus malma* occurs near Haines, Alaska. A two-year program was initiated in 1988 to study this fishery. During the fall of 1989 and spring of 1990 a mark-recapture experiment was conducted to estimate the number of Dolly Varden ≥ 231 mm fork length overwintering in Chilkat Lake, near Haines. Creel surveys were conducted during the spring of 1990 to estimate angler effort, harvest, and catch in Chilkat River roadside fishery near Haines. Fork lengths, age, weight, and sex of adults captured at the Chilkat Lake outlet and in selected Haines sport fisheries were also recorded.

During October 1989, 3,877 Dolly Varden ≥ 231 mm fork length which were aggregated along beaches of tributaries entering Chilkat Lake were captured with beach seines and marked. Technicians operating a weir located in the outlet stream of Chilkat Lake during March, April, and May 1990 examined 38,729 Dolly Varden for marks and recaptured 1,190 marked fish. Nearly the entire spring emigration of fish ≥ 350 mm fork length was believed to be captured at the weir and inspected for marks. An estimated 151,773 (SE = 6,732) Dolly Varden between 231 mm fork length and 480 mm fork length spent the winter in Chilkat Lake during the winter of 1989-90. Although only a fraction of each size class marked in the lake was observed in the spring emigration, marked fish not observed at the weir were recovered in summer fisheries across northern Southeast Alaska.

In the Haines roadside fishery, approximately 3,001 angler hours of effort (SE = 441) were expended to catch an estimated 5,269 (SE = 1,798) and harvest an estimated 3,558 (SE = 1,218) Dolly Varden between March 26 and April 29, 1990.

Length, weight, sex, and age were recorded for 107 Dolly Varden mortalities associated with the weir operating on the outlet to Chilkat Lake during the spring of 1990, and for an additional 220 Dolly Varden sampled from angler creels in the Haines area. Tagged Dolly Varden were captured up to 202 km by water from Chilkat Lake.

KEY WORDS: Dolly Varden, *Salvelinus malma*, Southeast Alaska, Chilkat Lake, Chilkat River, abundance, weir, emigration, migrations, age, weight, length composition, creel survey, angler effort, harvest, fishery contributions, Haines.

INTRODUCTION

Anadromous Dolly Varden *Salvelinus malma* are the focus of large recreational fisheries in Southeast Alaska. Anadromous Dolly Varden reside in lakes and large rivers during winter, migrate to sea in the spring or early summer, and return to their natal streams or lakes to spawn in the fall. In Southeast Alaska, immature Dolly Varden migrate to sea at ages II-IV, may migrate between several freshwater systems during a given year, and may overwinter in a non-natal system (Armstrong 1974). Dolly Varden marked in Southeast Alaska have been recaptured at sea 152 km (95 mi) from their natal systems and in freshwater systems 115 km (72 mi) from their natal systems (Armstrong 1965).

The recreational fishery for Dolly Varden near Haines and Skagway, Alaska expanded from an estimated annual harvest of about 10,000 fish in 1978 to about 30,000 fish in 1985 (Mills 1990; Table 1). These harvests are from the Alaska portion of all drainages into northern Lynn Canal, with most of the harvest occurring in fresh water. Until 1989 most of this harvest occurred in the Chilkat River drainage, excluding Chilkat Lake (Table 1). Since 1986, harvests of Dolly Varden in the Chilkat River and estimated total harvests in the Haines/Skogway area appear to be declining; for example, the estimated total harvest of Dolly Varden in 1989 is about 50% below the estimates for 1985 and 1986. The impetus for this study, which terminates with this report, was the decline in these harvests in recent years. We assumed that Chilkat and Chilkoot lakes provide the most important wintering habitats for Dolly Varden in Lynn Canal, and we began to study Chilkat Lake.

Chilkat Lake is located 29 km northwest of Haines (Figure 1). The lake is 10 km long, has a surface area of 984 hectares, a surface elevation of ≈ 53 m, and a maximum depth of 57 m (Barto and Koenings, 1989). It has substantial littoral areas, although the western perimeter of the lake drops abruptly. The lake outlet is ≈ 1.6 km in length and flows into the Tsirku River, a tributary of the Chilkat River. The largest targeted Dolly Varden fishery in the area occurs early in spring along the Haines Highway adjacent to the Chilkat River; this fishery usually starts in late March and continues through May. The fishery is popular with residents of Haines and residents of Whitehorse, Yukon Territory, Canada, who are eager to escape their harsh winter weather. Another popular Dolly Varden fishery occurs during summer at Chilkoot Lake and River (Table 1).

The objectives of this study are to estimate:

1. abundance of Dolly Varden ≥ 220 mm fork length (FL) residing in Chilkat Lake during the winter of 1989-1990;
2. catch, harvest, and fishing effort along the roadside fishery in Haines from March 26 through May 20, 1990; and
3. contribution of Dolly Varden which overwintered in Chilkat Lake to the Haines sport fishery from March 26 to May 20, 1990.

In addition, length, weight, and age of Dolly Varden sampled at a weir on the Chilkat River and during three creel surveys near Haines, and seasonal growth and migrations tabulated from tagging data, are presented.

Table 1. Estimated harvest of Dolly Varden and effort in angler days in the Haines/Skagway and Sitka areas, 1978-1989.

HAINES/SKAGWAY AREA DOLLY VARDEN HARVESTS														
Year	<u>Chilkoot River</u>		<u>Chilkoot Lake</u>		<u>Chilkat River</u>		<u>Chilkat Lake</u>		<u>Saltwater</u>		<u>Freshwater</u>		<u>Total</u>	
	Harvest	Effort ^a	Harvest	Effort ^a	Harvest	Effort ^a	Harvest	Effort ^a	Harvest	Effort ^a	Harvest	Effort ^a	Harvest	Effort ^a
1978 ^b	1,953	3,533	1,483	2,757					2,775	8,035	7,215	9,866	9,990	17,901
1979 ^c	554	1,478	1,327	1,587					1,373	5,203	2,690	4,526	4,063	9,729
1980 ^d	1,765	3,884	2,066	1,985					1,455	7,654	7,593	10,510	9,048	18,164
1981 ^e	5,098	6,364	2,354	1,947					2,149	10,144	11,366	10,617	13,515	20,761
1982 ^f	4,067	4,470	1,572	2,184					1,813	10,339	8,590	9,315	10,403	19,654
1983 ^g	3,564	6,637	3,542	2,959					4,164	13,100	14,208	17,081	18,372	30,181
1984 ^h	6,630	8,249	3,900	2,139	6,260	4,043			3,822	17,629	17,245	15,073	21,067	32,702
1985 ⁱ	9,069	11,362	5,185	4,365	12,346	5,845			2,756	17,344	28,195	23,068	30,951	40,412
1986 ^j	6,823	6,988	2,720	1,767	11,202	8,669	3,296	1,131	4,356	23,827	27,637	20,043	31,993	43,870
1987 ^k	4,075	10,377	5,668	6,501	7,063	4,763	543	2,083	1,232	17,130	17,891	28,881	19,123	46,011
1988 ^l	4,075	6,385	2,819	3,383	7,913	6,148	1,182	1,019	3,257	21,368	16,825	18,801	20,082	40,169
1989 ^m	2,352	11,387	5,315	2,707	3,762	4,431	1,227	2,707	2,181	21,171	13,935	26,847	16,116	48,018

^a Effort = Total effort for all species in angler days.

^b Mills (1980).

^c Mills (1981a).

^d Mills (1981b).

^e Mills (1982).

^f Mills (1983).

^g Mills (1984).

^h Mills (1985).

ⁱ Mills (1986).

^j Mills (1987).

^k Mills (1988).

^l Mills (1989).

^m Mills (1990).

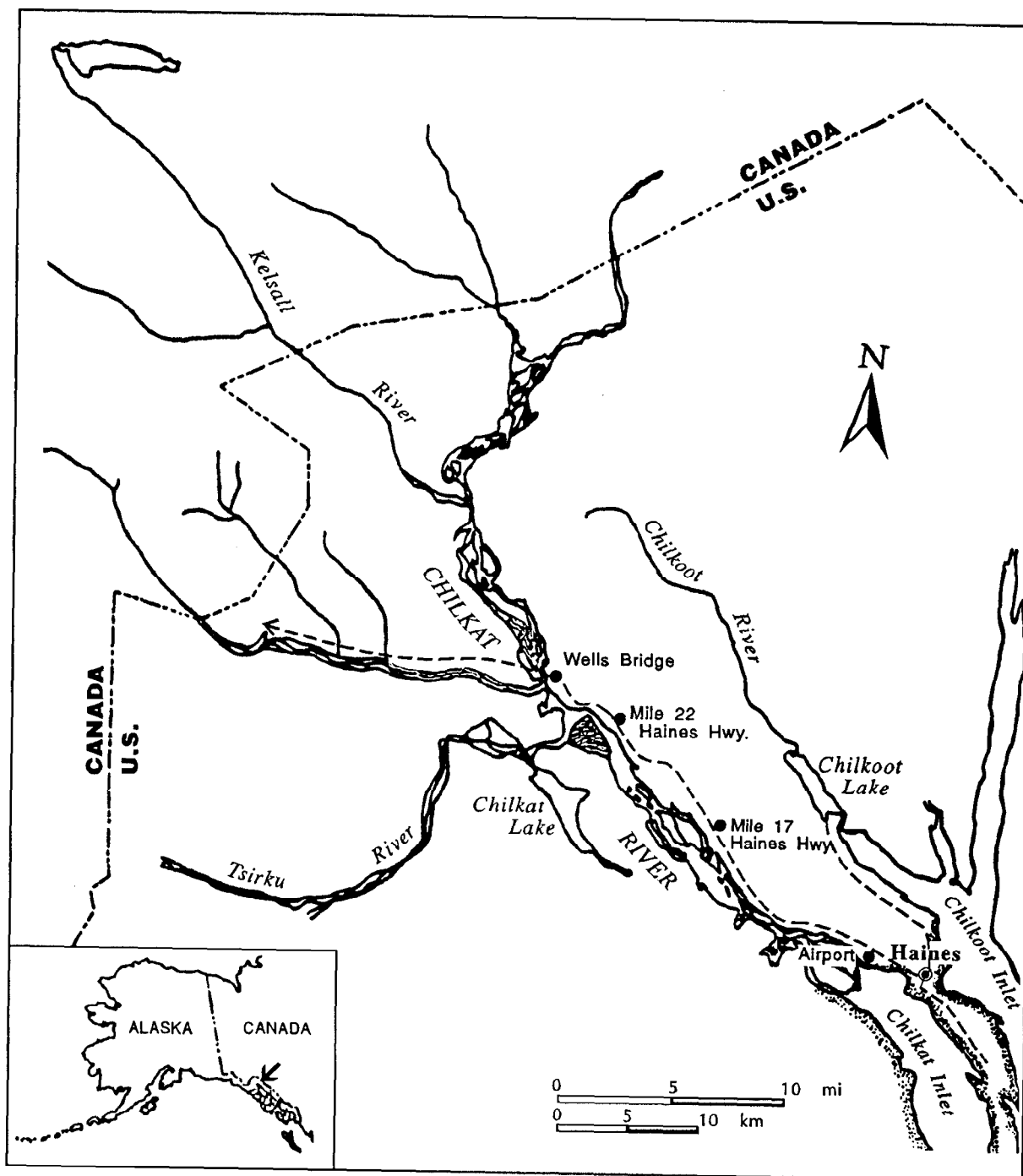


Figure 1. Roadside fishing areas around Chilkat Lake and Haines, northern Southeast Alaska.

METHODS

Estimation of Abundance

The number of Dolly Varden ≥ 220 mm FL in Chilkat Lake during the winter of 1988-1989 was estimated using a two-event mark-recapture experiment. Seines were used to capture fish as they aggregated on beaches at five lake-tributary junctions (Figure 2) between October 10 and November 1, 1989. A weir located about 1 km below the lake was used to attempt to capture and inspect for marks all emigrant Dolly Varden ≥ 220 mm FL leaving Chilkat Lake between March 21 and May 20, 1990.¹ Chapman's modified Peterson estimators (Seber 1982) were used to estimate abundance:

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \quad (1)$$

$$V[\hat{N}] = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \quad (2)$$

where \hat{N} = abundance,
 n_1 = number of Dolly Varden marked in fall 1989,
 n_2 = number of Dolly Varden examined in spring 1990, and
 m_2 = number of marked Dolly Varden recaptured in spring 1990.

Results from a previous investigation (Erickson et al. 1990) suggest recruitment into the tagged population might occur between sampling events. When this happens, the abundance estimate applies to the population after the recruitment, assuming negligible deaths occur between sampling events.

All Dolly Varden tagged in October 1989 were marked by a hole punched into their left ventral fin to provide a secondary mark for estimating tag loss. The occurrence of natural marks resembling hole-punches in left ventral fins was investigated during the first sampling event.

The length frequency distribution of fish captured at the weir was estimated by sampling from the fish captured and held in the live box each day. A systematic sample of 1 in 10 fish was employed for this purpose, except when the emigration rate was very high ($> \approx 1,000$ fish/day). When this occurred we used a dip net to sample ≈ 100 fish each day from the live box. After the experiment, the smallest daily sampling fraction obtained (i.e., the lowest proportion sampled per day) and the total number emigrating each day were multiplied together to determine the number of length measurements to subsample from each daily data collection in order to obtain a representative sampling of the emigration.² All Dolly Varden recaptured with a Floy tag were measured for length to the nearest mm.

The weir below Chilkat Lake was constructed of 2-by-6-inch lumber frame panels and covered with 1/2-inch mesh vexar. Sandbags were placed along the bottom and

¹ An obvious exception occurred on April 20 when the boat gate was lowered to pass lake ice downstream.

² On May 13 the live box was modified to separate fish above and below 220 mm FL into 2 groups. Subsampling for lengths after May 13 was thus more involved, but similar in principle, to that described.

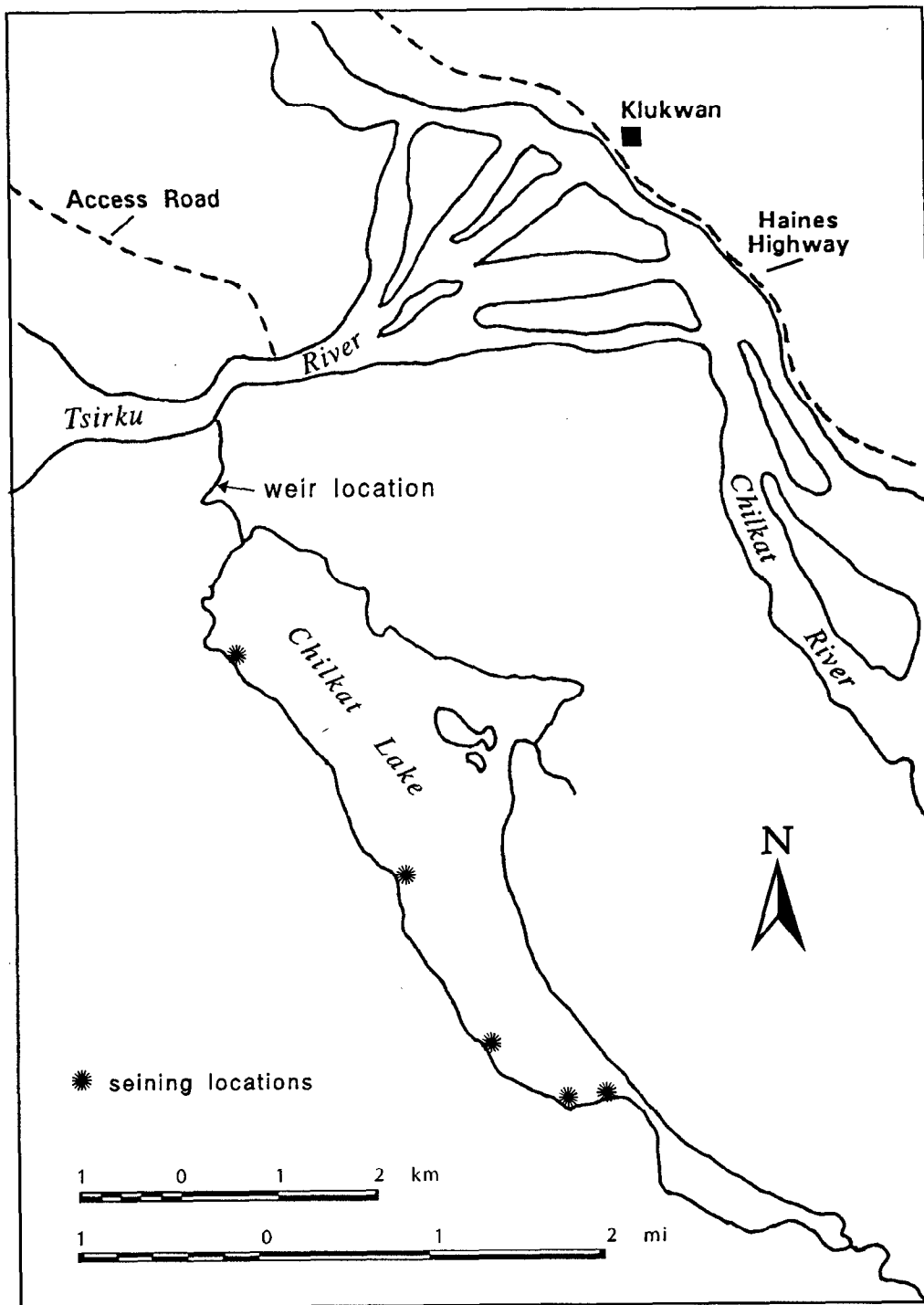


Figure 2. Location of sampling sites and weir at Chilkat Lake, northern Southeast Alaska.

sides of the weir to make it fish-tight. A hinged gate at the main thalweg of the outlet was attached to the weir to pass boats. A 2-by-3-m fyke net was secured to the gate and connected to a live box with a plastic pipe 300 mm in diameter. Dolly Varden migrating downstream from the lake passed into the fyke net, through the pipe, and into the live box where they were held until they could be sampled. Fish could bypass the live box when the gate was down to pass boats, although observation indicated most fish avoided approaching boats, scattered away from the gate, and did not avoid capture.

Creel Survey

A stratified, three-stage roving creel survey based on expansion of sample ratios was used to estimate both fishing effort and harvest of Dolly Varden between Mile 3 and Mile 24 of the Haines Highway (Figure 1). Five weekly (7-day) seasonal strata and weekday versus weekend-holiday stratification were maintained. There were thus 10 discrete strata. Days were primary sampling units, periods within days were secondary sampling units, and anglers within periods were tertiary sampling units.

Four weekend-holiday and 4 weekdays per 7-day period were randomly selected for sampling. In each day selected for sampling, 2 of 3 or 4 (depending on strata) possible periods were randomly selected to sample. The available sampling periods were equal in length and fixed at between 195 and 240 minutes, depending on day-length, and together equaled the length of time from 0700 hours to average civil twilight during the strata.

During each sampling period, a technician both counted and interviewed anglers along the Haines Highway. Angler counts were conducted once in each period at a randomly selected time (beginning, middle, or end) in the period. When not counting anglers the technician moved through the fishery to interview anglers while they fished and at the end of their trip. Anglers concentrated around major parking areas and were counted and interviewed by a technician roving near the parked vehicles. Data was recorded from three areas: (1) airport (Mile 3) to Mile 17, (2) Mile 17 to Mile 22, and (3) Well's Bridge area (around Mile 24). However, survey results were not stratified using these areas.

The harvest (or catch) in each stratum is estimated by

$$\hat{C}_h = D_h \bar{C}_h \quad (3)$$

$$\bar{C}_h = \frac{\sum_{i=1}^{d_h} \hat{C}_{hi}}{d_h} \quad (4)$$

$$\hat{C}_{hi} = Q_h \bar{C}_{hi} \quad (5)$$

$$\bar{C}_{hi} = \frac{\sum_{j=1}^{q_h} \hat{C}_{hij}}{q_h} \quad (6)$$

where \hat{C}_{hij} is the estimated harvest in period j day i stratum h, q_h is the number of periods sampled in a day, Q_h is the number of periods in a day, d_h is the number of days sampled in stratum h, and D_h is the total number of days in stratum h. The variance of the harvest in each stratum is estimated by

$$V[\hat{C}_h] = (1-f_{1h}) D_h^2 \frac{\sum_{i=1}^{d_h} (\hat{C}_{hi} - \bar{C}_h)^2}{d_h (d_h - 1)} + D_h Q_h^2 \sum_{i=1}^{d_h} (1-f_{2h}) \frac{\sum_{j=1}^{q_h} (\hat{C}_{hij} - \bar{C}_{hi})^2}{d_h q_h (q_h - 1)} + D_h Q_h \frac{\sum_{i=1}^{d_h} \sum_{j=1}^{q_h} \hat{V}[\hat{C}_{hij}]}{d_h q_h} \quad (7)$$

where $f_{1h} = d_h/D_h$ and $f_{2h} = q_h/Q_h$.

The harvest for each sampling period is estimated by

$$\hat{C}_{hij} = \hat{E}_{hij} \overline{CPUE}_{hij}^* \quad (8)$$

where \overline{CPUE}_{hij}^* is the "jackknife" estimate of mean CPUE during stratum h, day i, sampling period j; and E_{hij} is the fishing effort in angler hours during the same time.

Since anglers were counted only once per period, the variance of \hat{C}_{hij} is estimated by

$$V[\hat{C}_{hij}] = \hat{E}_{hij}^2 V[\overline{CPUE}_{hij}^*] \quad (9)$$

The \overline{CPUE}_{hij}^* and its variance are calculated according to procedures in Efron (1982). The inherent correctable bias of m_{hij}^{-2} (the number of interviews in a sampling period) of our jackknife estimates are mitigated according to the procedure in Efron (1982, p.6).

Effort in each period is estimated by

$$\hat{E}_{hij} = H_h x_{hij} \quad (10)$$

where x_{hij} is the number of anglers counted during stratum h, day i, sampling period j. If $x_{hij} = 0$ and anglers are interviewed, then \hat{C}_{hij} in (8) was set equal to the observed catch. In contrast, if $x_{hij} > 0$ and anglers are not interviewed, then \overline{CPUE}_{hij}^* in (8) was set equal to the mean \overline{CPUE}_{hij}^* for the stratum.

Total angler effort in each stratum is estimated using equations 3-6 (only E is substituted for C). The variance of the effort in each stratum is estimated by

$$V[\hat{E}_h] = (1-f_{1h}) D_h^2 \frac{\sum_{i=1}^{d_h} (\hat{E}_{hi} - \bar{E}_h)^2}{d_h (d_h - 1)} + D_h Q_h^2 \sum_{i=1}^{d_h} (1-f_{2h}) \frac{\sum_{j=1}^{q_h} (\hat{E}_{hij} - \bar{E}_{hi})^2}{d_h q_h (q_h - 1)} \quad (11)$$

since variance of E_{hij} cannot be estimated with only 1 count per sample.

Harvest, catch, and effort for the entire season (and their variances) are the sums of the estimates for each strata.

A student's t-test was used to compare differences between CPUE obtained from complete-trip and incomplete-trip interviews. CPUE data from all strata were lumped together to conduct the test. The t-test was

$$t = \frac{\overline{CPUE}_I^* - \overline{CPUE}_C^*}{(V[CPUE_I^*] + V[CPUE_C^*])^{1/2}} \quad \text{vs.} \quad t_{\alpha, df} \quad (12)$$

where the subscript "I" denotes incomplete-trip interviews and "C" complete-trip interviews. The degrees of freedom (Steele and Torrie 1980, p.106) are

$$df = \frac{(V[CPUE_I^*] + V[CPUE_C^*])^2}{\frac{(V[CPUE_I^*])^2}{(n_I - 1)} + \frac{(V[CPUE_C^*])^2}{(n_C - 1)}} \quad (13)$$

Contribution Estimates

The contribution to selected sport fisheries of Dolly Varden ≥ 350 mm FL emigrating from Chilkat Lake was facilitated by marking all emigrant Dolly Varden ≥ 350 mm FL sampled at the weir with a shallow clip of the upper caudal fin. Greater than 96% of the Dolly Varden sampled in Chilkat River roadside sport fishery in 1989 were ≥ 350 mm FL (Erickson et al. 1990). Sampling for these marked fish occurred in (1) the Chilkat River roadside sport fishery (March 26-April 29, this study); (2) the Chilkoot River roadside sport fishery (June 25-November 4)(Erickson and Marshall 1991a); (3) the Chilkat Lake cutthroat *O. clarki* trout fishery (May 21-October 7)(Erickson and Marshall 1991b); (4) the Haines marine sport fishery landings in Letnikof Harbor (April 23-June 21)(Suchanek and Bingham 1991a); (5) the Juneau marine sport fishery (April 23-September 23)(Suchanek and Bingham 1991a); and (6) selected fisheries on the Juneau roadside (May 7-November 4)(Suchanek and Bingham 1991b).

Dolly Varden sampled in each of these fisheries were inspected for a caudal fin clip and for tags placed during the first and second sampling experiments and were measured for length, if possible. The contribution \hat{C}_{t_h} of emigrant Chilkat Lake Dolly Varden to a sampled fishery in stratum h was estimated:

$$\hat{C}_{t_h} = \frac{m_{c_h}}{\hat{\phi}_h \theta} \quad (14)$$

where m_{c_h} is the number of marked Dolly Varden found in the inspected harvest, $\hat{\phi}_h$ is the fraction of the harvest in the sport fishery that was inspected, and θ is the fraction of the stock of interest marked. Since we do not know how many emigrant Dolly Varden ≥ 350 FL were unmarked, we used a marking fraction of 1.0; the contribution estimates thus represent minimums for all emigrants ≥ 350 FL.

The variance of \hat{C}_{t_h} was estimated:

$$\hat{V}[\hat{C}_{t_h}] = \hat{C}_{t_h}^2 \left[\frac{V[\hat{H}_h]}{\hat{H}_h^2} \frac{(m_{c_h} - 1)}{m_{c_h}} + \frac{1}{m_{c_h}} \right] \quad (15)$$

where \hat{H}_h is estimated harvest of Dolly Varden (all stocks) in the sport fishery in stratum h. This variance is an approximation to corresponding formula in Clark and Bernard (1987, p.24), which we employ because harvest in stratum h is

an estimate. The approximation is $(\hat{C}_{t_h}-1) \approx \hat{C}_{t_h}$, $(H_h-1) \approx H_h$, and $(n_2-1) \approx n_2$ (where n_2 is the number of fish inspected for marks) in equation 12 of Clark and Bernard (1987). Equation 15 (above) results when the contribution (equation 14, above) is recast as the product of a constant $1/(\theta \cdot n_2)$ times two random variables (m_{c_h} and H_h) and Goodman's formula (1960) for the variance of a product of random variables is employed.

Contributions for the season are the sums across strata $\sum_{h=1}^L \hat{C}_{t_h}$ and $\sum_{h=1}^L \hat{V}[\hat{C}_{t_h}]$.

Migrations

Three thousand nine hundred and four (3,904) Dolly Varden captured in October 1989 and 1,683 emigrant Dolly Varden captured at the weir between April 12 and May 3, 1990 were marked with uniquely numbered t-bar anchor tags imprinted with the name and phone number of the ADFG office in Haines. Numbered tags were placed on fish at the weir to increase the amount of information regarding migration routes that could be collected from remote and unsampled fisheries.

Fish tagged during fall (event 1) ranged between 198 and 508 mm FL ($\bar{X} = 335$ mm FL, $SD = 42$ mm FL). In contrast, 98% of the Dolly Varden tagged during the spring emigration were >350 mm FL, since we tried not to tag small fish.

Age, Weight, and Length

Length, weight, sex, and sagittal otoliths were collected from dead Dolly Varden sampled at the weir and in creel surveys near Haines (see list above). Fork length was measured to the nearest millimeter, and weight to the nearest 10 g. Both sagittal otoliths were removed for age determination if possible. Otoliths were stored dry, then soaked in a 50% glycerine and 50% water solution for about 48 hours before grinding by hand with number 220 wet/dry sandpaper. Age was determined by counting the number of hyaline zones on otoliths placed on a watch glass and viewed against a dark background with reflected light. A stereoscopic microscope with a ten-power ocular and a one-power objective was used for examinations.

Overwinter growth was obtained from length measurements of individual Dolly Varden tagged during the first sampling event and then recovered at the weir. Standard procedures were used to estimate average overwinter growth. A smoothed trend was also fit to a scatterplot of the growth data using the LOWESS algorithm (Cleveland 1979) and a smoothing window of 0.3 times the width of the data.

RESULTS

Estimation of Abundance

Three thousand eight hundred and seventy seven (3,877) Dolly Varden between 223 mm FL and 508 mm FL were captured, tagged, and released in Chilkat Lake during 62 beach seine sets (Figure 3, top). Based upon nonqualitative observation, larger Dolly Varden captured during this time were in post-spawning condition as evidenced by darker coloration, hooked noses, and low body weight. Catch rates were high during mid-October and declined rapidly after October 20 (Figure 4), about the same time as the fall overturn of Chilkat Lake in 1989 (Richard Yanusz, Alaska Department of Fish and Game, Douglas, personal communication). Dolly Varden probably moved to deeper water as the lake became isothermic and thus were

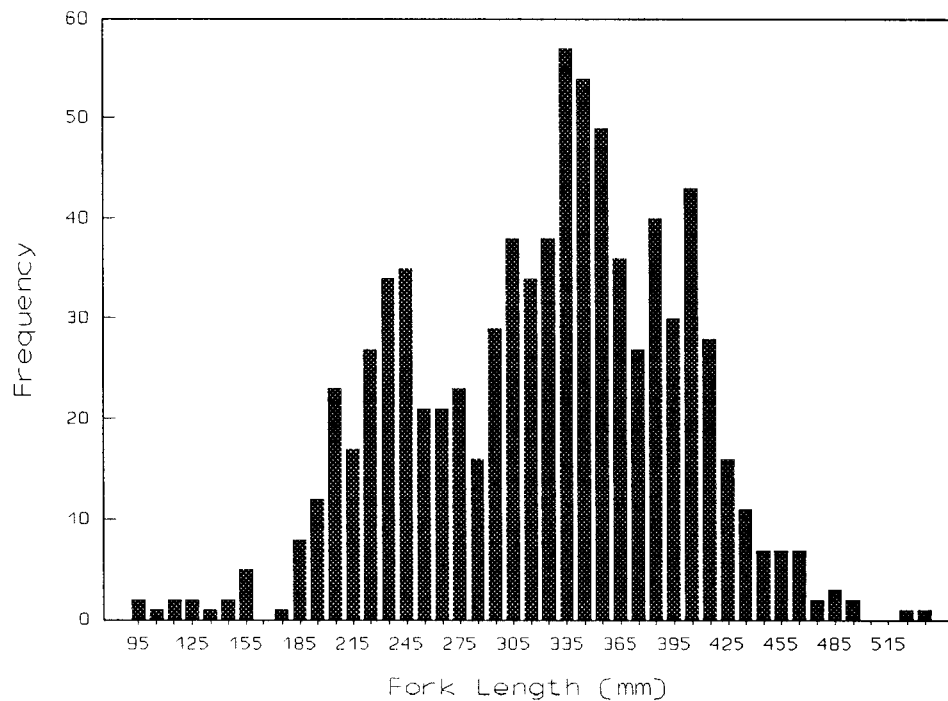
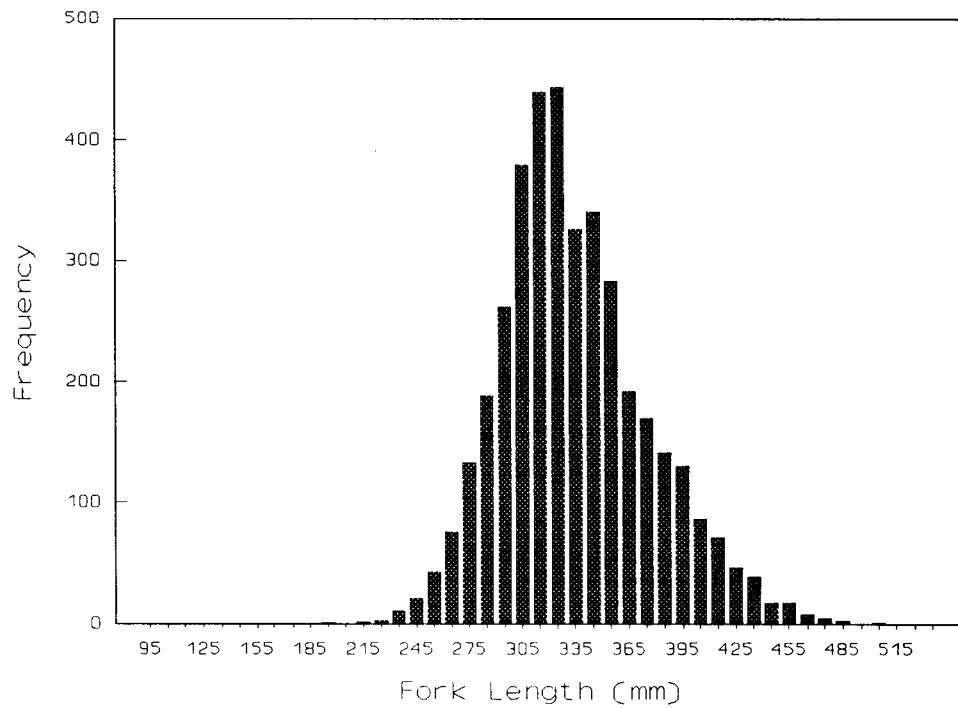


Figure 3. Length frequency of Dolly Varden captured at Chilkat Lake in fall 1989 (top) and of sample of emigrant Dolly Varden captured at the lake outlet during spring 1990 (bottom). Fork lengths on the ordinate indicate the mid-point of 10 mm intervals.

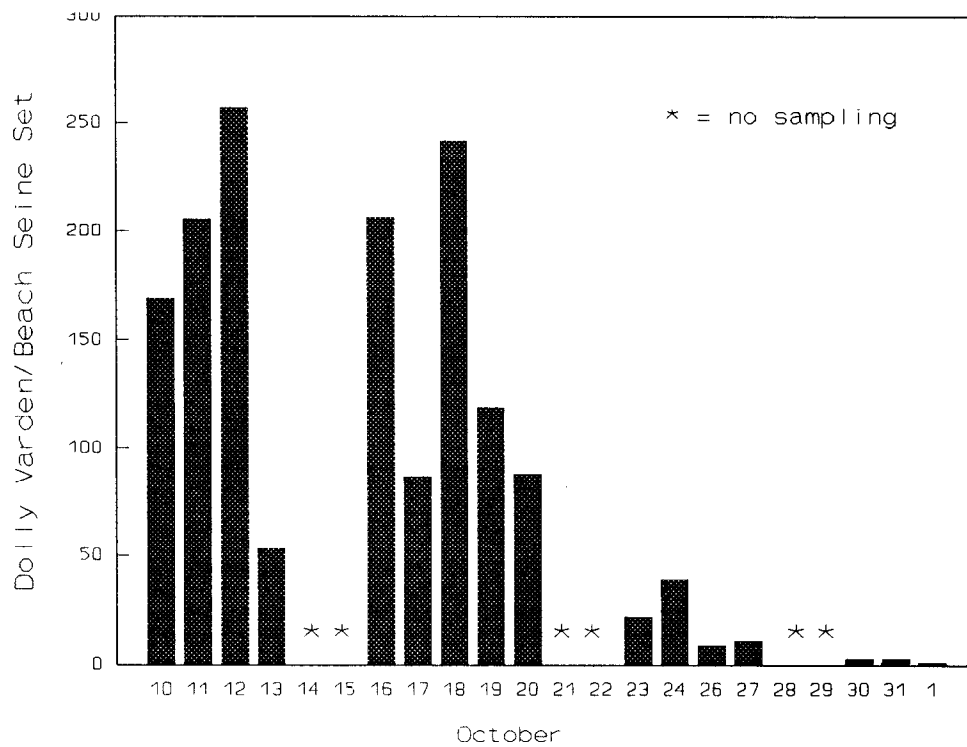


Figure 4. Daily catch per beach seine set during the fall 1990 sampling event. The sharp decline in CPUE values corresponds approximately with the fall overturn of Chilkat Lake in 1989 (Richard Yanusz, Alaska Department of Fish and Game, Douglas, personal communication).

not available to our beach seine. We observed no marks on left ventral fins resembling hole-punches during the fall sampling.

A total of 44,099 Dolly Varden was counted through the weir. The emigration began on April 15, after the water temperature of the lake outlet reached 6°C just prior to ice-out (April 20), and peaked during the second week of May, with large Dolly Varden tending to emigrate first (Figure 5). Of those counted, 40,932 were ≥ 220 mm FL (Figure 3, bottom), and these were examined for tags and ventral punch marks. Although the weir was installed well before the emigration began, more than 500 Dolly Varden between 220 mm FL and 350 mm FL were passing through the weir each day when counting stopped on May 20 (Figure 5).

A total of 1,190 Dolly Varden marked during the fall of 1989 was recaptured at the weir. Recaptured Dolly Varden ranged from 231 mm to 480 mm FL, so abundance was estimated for fish within this size range. Only five of the 1,190 recaptured fish (0.004%) were missing floy tags; tag loss was therefore considered insignificant and ignored.

The cumulative distribution function (CDF) of lengths of Dolly Varden marked in fall 1989 differs significantly from the CDF of Dolly Varden recaptured at the weir during spring 1990 (K-S test, $d_{\max} = 0.185$, $p < 0.0001$) (Figure 6, top). This suggests the second sampling event was size selective, since little growth of tagged fish (3 mm FL on average, see below) occurred between sampling events. Although the weir itself was nonselective at capturing fish of different size, we stopped sampling Dolly Varden prior to the end of the emigration, when smaller Dolly Varden were still emigrating in large numbers (Figure 5). Since size selectivity was present in the second sampling event, estimates of abundance were made for stratified and unstratified (by length category) groups of fish. The estimate based on unstratified data (125,880, SE = 2,987) was significantly below the estimate using stratified data, so the unbiased (stratified) estimate was adopted. A series of chi-square tests (Table 2) was used to determine length strata for stratifying estimates of abundance.

An estimated 151,773 (SE = 6,732) Dolly Varden >230 mm and ≤ 480 mm FL were present at, or overwintered in, Chilkat Lake during the winter of 1989-1990. An estimated 69,267 (SE = 6,414) Dolly Varden >230 mm and <300 mm FL ($n_1 = 686$, $n_2 = 9,880$, $m_2 = 97$), 47,884 (SE = 1,763) Dolly Varden ≥ 300 mm and <350 mm FL ($n_1 = 1,944$, $n_2 = 12,752$, $m_2 = 517$), and 34,682 (SE = 1,038) Dolly Varden ≥ 350 mm and ≤ 480 mm FL ($n_1 = 1,240$, $n_2 = 16,097$, $m_2 = 576$) overwintered in Chilkat Lake.

Recruitment into the marked population was obvious between sampling events (Figure 3 and Figure 6, bottom). Thus, estimates of abundance refer to abundance after the recruitment (immigration), which we label a part of the "overwintering" population.

Creel Survey

Warm sunny weather created high and turbid flows on the Chilkat River by late April. As a result, sport fishing effort dropped 93% between the third and fourth weekly periods, few anglers remained fishing, and sampling was suspended on April 30, well before most emigrant Dolly Varden tagged in this study reached the spring sport fishery on the Chilkat River.

Complete- and incomplete-trip CPUE were found to be significantly different ($\overline{CPUE}_c = 1.39$, $\overline{CPUE}_i = 0.64$, $t = -2.86$, $df = 67$, $P < 0.01$). A similar result was

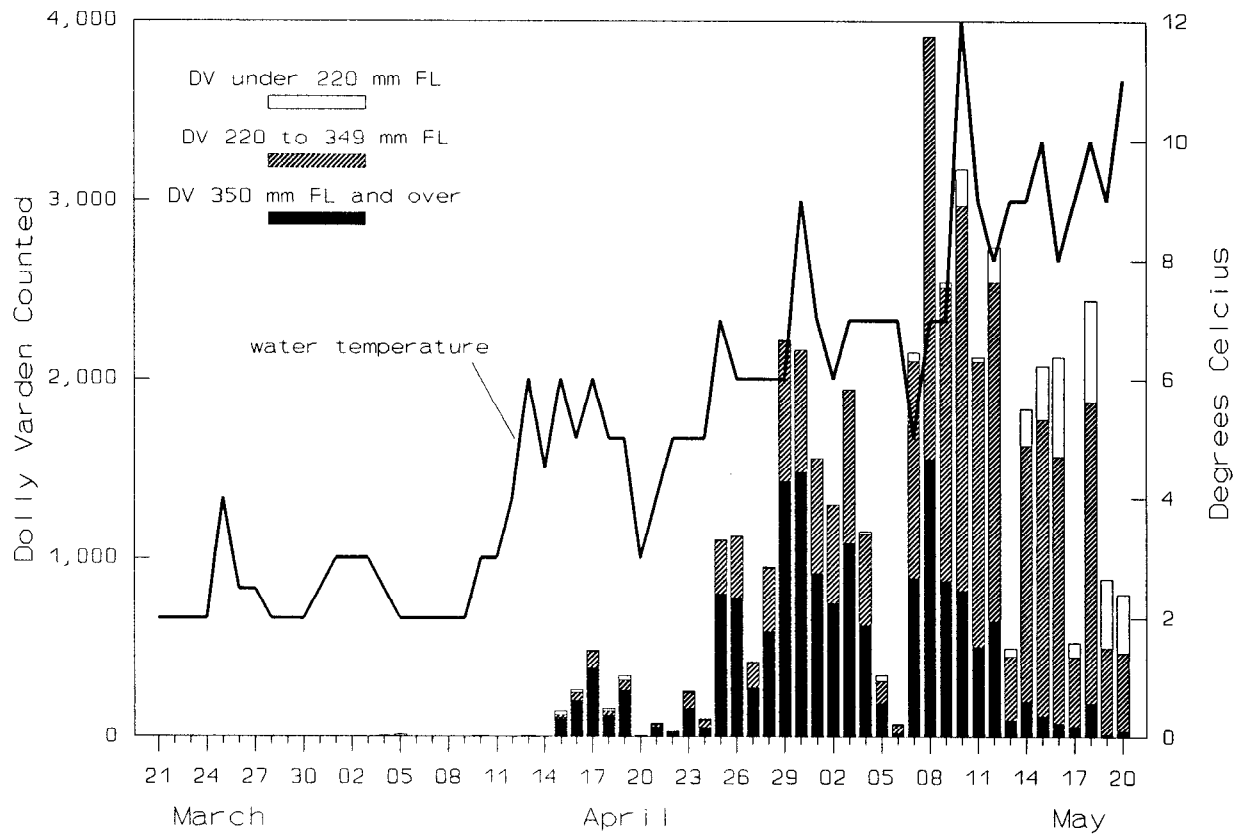


Figure 5. Daily count of Dolly Varden, by size group, through the Chilkat Lake outlet weir, and the daily water temperature during second sampling event. Larger Dolly Varden tended to outmigrate first.

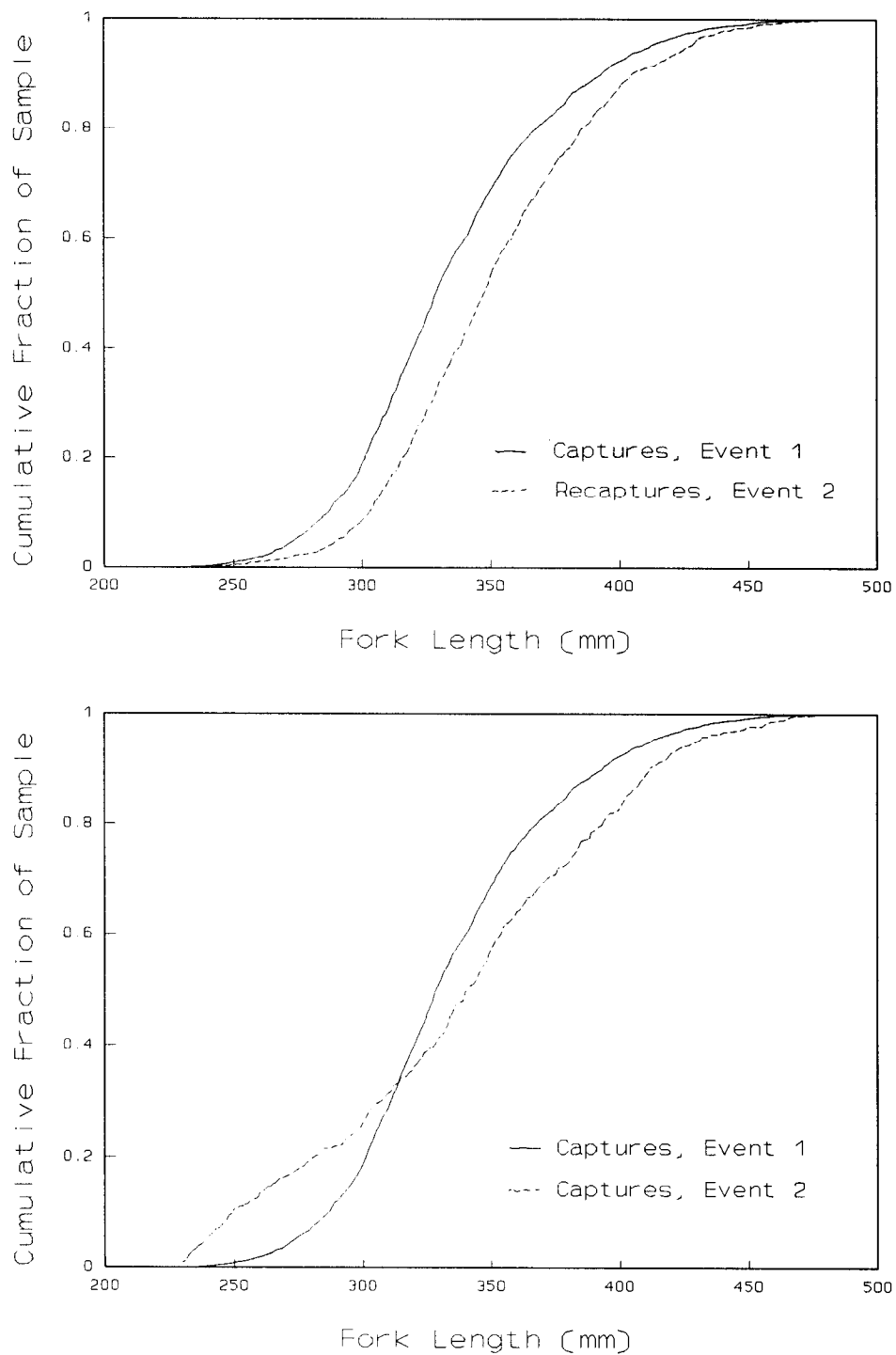


Figure 6. The cumulative distribution function (CDF) of lengths (FL) of Dolly Varden marked in Chilkat Lake versus lengths of emigrant Dolly Varden recaptured (top) and versus lengths of emigrant Dolly Varden examined for marks (bottom).

Table 2. Results of chi-square tests to determine size categories for stratifying the mark-recapture experiment.

Length category	Length mm (FL)	Number recaptured	Number not recaptured	Proportion recovered
I	<249	4	24	0.14
II	250-299	92	566	0.14
III	300-349	510	1,434	0.26
IV	350-399	410	527	0.44
V	400-449	134	135	0.50
VI	>450	18	16	0.53

Hypothesis A:

$$H_0 = P_I = P_{II} = P_{III}.$$

Result: $\chi^2 = 42.84$, $df=2$, $p < 0.01$; reject H_0 .

Hypothesis B:

$$H_0 = P_{IV} = P_V = P_{VI}.$$

Result: $\chi^2 = 3.91$, $df=2$, $0.25 < p < 0.10$; accept H_0 .

Hypothesis C:

$$H_0 = P_I = P_{II}.$$

Result: $\chi^2 = 0.00$, $df=1$, $p \geq 0.90$; accept H_0 .

Hypothesis D:

$$H_0 = P_{III} = P_{(IV+V+VI)}.$$

Result: $\chi^2 = 123.5$, $df=1$, $p < 0.01$; reject H_0 .

CONCLUSION: Stratify experiment by three size classes:
 $P_{(I+II)} = 231-299$ mm; $P_{III} = 300-349$ mm; and,
 $P_{(IV+V+VI)} = 350-480$ mm FL.

recorded for HPUE ($\overline{HPUE}_C^* = 0.92$, $\overline{HPUE}_I^* = 0.43$, $t = -2.59$, $df = 64$, $P < 0.02$), so catch and harvest were estimated using only complete-trip interviews.

Fifty-four complete-trip interviews were conducted during 40 sampling periods to observe 107 angler-hours of effort, a catch of 150 Dolly Varden, and a harvest of 100 Dolly Varden (Table 3). An estimated total of 3,001 angler hours of effort ($SE = 441$) was expended to catch 5,269 ($SE = 1,798$) and harvest 3,558 ($SE = 1,218$) Dolly Varden during the roadside fishery between March 26 and April 29 (Table 4). Most of the estimated effort (76%), catch (81%), and harvest (76%) occurred during one weekly period (April 9-April 15). Angler effort and catch of Dolly Varden was distributed about evenly between three main areas of the river between river miles 3 and 24. Overall catch rates ($CPUE = \Sigma catch / \Sigma effort$) peaked early during the survey ($CPUE = 2.1, 1.8, 1.9, 0$, and 0 fish/angler-hour, for weeks 1-5, respectively), about 2 weeks ahead of the peak catch and harvest (Table 4).

Contribution Estimates

All 16,462 Dolly Varden ≥ 350 mm FL counted at the weir were captured and marked with a shallow caudal clip. The marked fish were sampled infrequently at each of the randomly sampled sport fisheries monitored for this study (Table 5) and in other locations in Southeast Alaska, as described below.

Marked Dolly Varden were first sampled toward the end of the spring sport fishery on the Chilkat River. Marked fish were sampled next in the Haines marine sport fishery, then in roadside and marine sport fisheries near Juneau (Table 5). Finally, marked Dolly Varden were sampled in August sport fisheries on the Chilkoot River and in late July in Chilkat Lake.

The estimated contribution of marked Dolly Varden to randomly sampled sport fisheries is 220 ($SE = 105$) Dolly Varden (Table 5).

Migrations

Five thousand nine hundred eighty-seven (5,987) Dolly Varden were tagged during this study. Tagged Dolly Varden were recovered in all directions from Chilkat Lake. Ninety-three (93) of these fish were voluntarily reported to us through July 31, 1991 (Appendix A1). Fifty-two (52) of these fish were recovered in sport fisheries in Haines, Juneau, Hoonah, and Gustavus. Thirty-six (36) were caught by Haines anglers (26 in freshwater and 10 in marine fisheries).

Juneau anglers fishing in salt water voluntarily reported catching 13 tagged fish, all north of the south end of Shelter Island. Six of these 13 fish were caught along the northern end of the Juneau Road system (4 at Sunshine Cove, and 2 at Echo Cove) in late May and June. One fish tagged at Chilkat Lake in fall 1988 was reported caught in the Antler River (a tributary of the Berners River) on September 9, 1990.

Two tagged Dolly Varden were reported caught from Hoonah. One was recovered in salt water and the other was caught in Game Creek (the orange-colored tag was sent to ADFG in Juneau, but subsequently lost). The farthest recovery was from a Dolly Varden captured 202 km (126 mi) by water from the Chilkat Lake outlet, in the Salmon River near Gustavus.

Eight tagged Dolly Varden were recovered and returned to us by commercial drift

Table 3. Observed angler effort (hours), number of interviews, number of periods sampled, number of possible sampling periods, and observed harvest and catch of Dolly Varden by site and sampling period, for anglers completing their fishing trips, 1990.

Sampling period	Angler effort	Number of interviews	Periods sampled	Periods possible	DV caught	DV kept
Weekend						
3/26-4/01	15.5	7	4	6	20	15
4/02-4/08	47.0	11	4	6	36	21
4/09-4/15	23.0	10	4	8	28	22
4/16-4/22	1.0	2	4	8	0	0
4/23-4/29	1.0	4	4	8	0	0
Weekday						
3/26-4/01	0	0	4	15	0	0
4/02-4/08	6.0	2	4	15	20	13
4/09-4/15	12.5	16	4	20	46	29
4/16-4/22	0	0	4	20	0	0
4/23-4/29	1.0	2	4	20	0	0

Table 4. Estimated total effort, catch, and harvest of Dolly Varden, with estimates of precision, for the Haines roadside by sampling period, March 26 through April 29, 1990.

	March 26 April 01	April 02 April 08	April 09 April 15	April 16 April 22	April 23 April 29	Total
<u>Angler hours</u>						
Estimate	240	290	2,278	141	52	3,001
Variance	6,360	7,861	177,446	642	1,822	194,131
SE ^a	80	89	421	25	43	441
Rel. prec. ^b	0.65	0.60	0.36	0.35	1.61	0.29
<u>Dolly Varden caught</u>						
Estimate	503	514	4,252	0 ^c	0	5,269
Variance	45,779	86,794	3,098,470	0	0	3,231,043
SE	214	295	1,760	0	0	1,798
Rel. prec.	0.83	1.12	0.81			0.67
<u>Dolly Varden kept</u>						
Estimate	481	369	2,708	0 ^c	0	3,558
Variance	51,013	38,179	1,395,449	0	0	1,484,641
SE	226	195	1,181	0	0	1,218
Rel. prec.	0.92	1.04	0.85	0	0	0.67

^a Standard error.

^b Relative precision = 1.96 SE / Estimate.

^c Based on incomplete interview data, a small catch and harvest occurred.

Table 5. Sampling parameters and estimated contributions of Dolly Varden ≥ 350 mm FL emigrating from Chilkat Lake between March 29 and May 20, 1990 to selected sport fisheries near Haines. Estimated total harvest H and its variance V(H), numbers of marked Dolly Varden inspected for marks (n_2), numbers of marked Dolly Varden recovered (m_c), fraction of tags inspected for marks ϕ , contribution C and its standard error SE(C) are shown by recovery strata and fishery.

Survey location	Survey target species	Survey dates	Recovery strata	H	V(H)	n_2	m_c	ϕ	C	SE (C)
Chilkat River	Dolly V.	3/26-4/29	4/16-4/22	141	642	2	2	0.014	141	101
Chilkoot River	Dolly V.	6/25-11/04	7/30-8/12	712	43,746	48	1	0.067	15	15
			8/13-8/26	399	20,037	33	1	0.083	<u>12</u>	<u>12</u>
		Subtotal							27	19
Chilkat Lake	Cutthroat	5/21-10/07	7/16-7/29	14	90	1	1	0.071	14	14
Haines marine	Chinook	4/23-6/21	5/07-5/20	24	NA	12	3	0.500	6	3
			5/21-6/03	148	1,334	47	3	0.318	9	6
			6/04-6/17	32	120	9	3	0.281	<u>11</u>	<u>7</u>
		Subtotal							26	10
Juneau marine	Salmon	4/23-9/23	5/21-6/03	250	3,674	33	1	0.132	8	8
Juneau roadside ^a	Salmon, Dolly V.	5/7-11/4	5/21-6/03	55	501	14	1	0.25	<u>4</u>	<u>4</u>
		Total							220	105

^a North of Mendenhall Peninsula.

NA = not available.

gill net fishermen in Lynn Canal. Two other fish were caught and reported by subsistence fishermen in the Chilkat River, and another was captured during an egg-take at the Burro Creek hatchery, near Skagway. One fish was recaptured by an environmental consultant conducting baseline studies for the Kensington Mine, located near Point Sherman, north of Berners Bay. The remaining 29 recoveries were caught during operation of ADFG fish wheels on the Chilkat River (15 fish) or during ADFG seining activities along the Chilkat River drainage (14 fish).

Fifty-one (51) Dolly Varden tagged during the fall (1989) marking event in Chilkat Lake were recaptured after the emigration sampling, or outside of Chilkat Lake after the emigration began (Appendix A1). Most (31) of these fish were *not captured at the weir* during the spring of 1990. Surprisingly, 6 of the 17 randomly recovered Dolly Varden which were ≥ 350 mm FL at the time of tagging were not captured during the spring emigration.

Age, Weight, and Length

One hundred seven (107) Dolly Varden mortalities were sampled at the weir for age, weight, length, and sex during the spring emigration; 65 of these fish were successfully aged (Figure 7 and Appendix A2). Sampled fish were 3 to 9 years of age, 174-450 mm FL (6.9-17.7 in.) long, and weighed 40-930 g (0.1-2.1 lb).

A total of 220 Dolly Varden was sampled from sport fisheries in the Haines area in 1990, and 193 of these fish were successfully aged. Fifty-eight of the 220 Dolly Varden were sampled from the spring fishery on the Chilkat River (Figure 7 and Appendix A3); 35 of the 220 Dolly Varden were sampled (31 were aged) from the summer cutthroat trout fishery on Chilkat Lake (Figure 7 and Appendix A4). Another 127 of the 220 Dolly Varden were sampled (104 were aged) in the summer and fall fisheries along the Chilkoot River (Figure 7 and Appendix A5).

Dolly Varden sampled from the spring fishery along the Chilkat River (Appendix A3) were mostly (59%) females and most frequently 7 (36%) or 8 (41%) years of age. Fish sampled from spring fisheries along the Chilkat River also tended to be older (and larger) than those sampled from fisheries at Chilkat Lake during the summer or along the Chilkoot River during the summer and fall. Dolly Varden sampled from the Chilkat River fishery averaged 442 mm FL (SE = 6) and 694 g (SE = 36), with ranges from 337 mm FL to 561 mm FL (13.3-22.1 in.) and from 300 g to 1,450 g (0.7-3.2 lb).

Dolly Varden sampled from the summer fishery on Chilkat Lake (Appendix A4) were most frequently (59%) age 7. Sampled fish averaged 334 mm FL (SE = 10) and 400 g (SE = 35), ranging from 188 mm FL to 460 mm FL (7.4-18.1 in.) and from 150 g to 1,100 g (0.3-2.4 lb). Sex composition was nearly equal: 42% were females.

Dolly Varden sampled in the summer and fall fisheries along the Chilkoot River (Appendix A5) were predominately age 6 (27%) and 7 (36%). Sampled fish averaged 372 mm FL (SE = 5) and 558 g (SE = 23), ranging from 248 mm FL to 515 mm FL (9.8-20.3 in.) and from 160 g to 1,450 g (0.4-3.2 lb). Sex composition was nearly equal: 52% were females.

A tremendous range in overwinter "growth" was observed from tag recoveries. Recovered fish were at large an average 201 days (minimum 161 days, maximum 223 days), and grew an average of 3.1 mm FL (SD = 15 mm) or 0.015 mm/day FL (SD = 0.07 mm/day). Among the 1,162 recoveries, growth of 37 fish might be considered "outliers" (outside $\bar{X} \pm 2$ SD): 19 fish grew from 35 mm FL to 122 mm FL, and 18

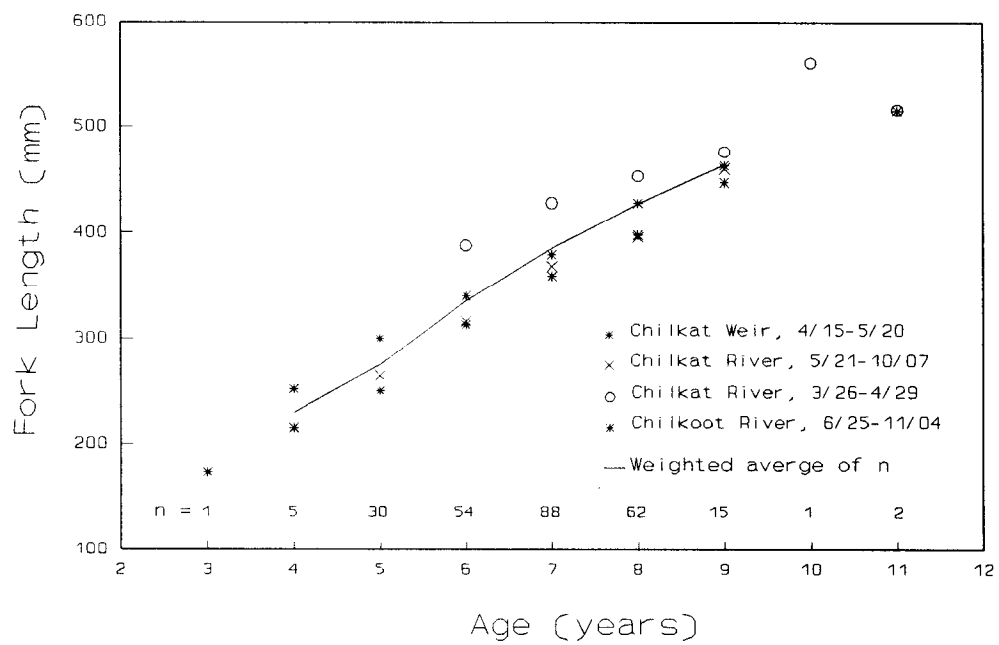


Figure 7. Mean length at age for Dolly Varden sampled at the Chilkat River weir and from selected sport fisheries in 1990.

fish "grew" from -27 mm FL to -129 mm FL. In general, average overwinter growth tended to be positive, but <5 mm FL for fish $\leq \approx 400$ mm FL, and near 0 mm FL for fish longer than 400 mm FL (Figure 8). Some scatter in the growth data is probably due to measurement error, such as that observed by Roth and Alexandersdottir (1990, p.33). However, tagging is a stressful procedure and probably contributed to the observed scatter in the data.

DISCUSSION

The accurate use of Peterson estimators requires several assumptions, including that both growth recruitment (or immigration) and emigration (or deaths) do not occur between sampling events. Little overwinter growth was observed among tagged fish, but some recruitment to the marked population did occur. In Lake Eva, Armstrong (1965) found that about 10.7% and 2.7% of the total annual immigration occurred in October and November, respectively. Thus, immigration after October (when marking occurred) was probably short and occurred before much mortality could happen, which suggests the abundance estimate is applicable to immigrating fish ≥ 230 mm FL. We do not know if significant numbers of deaths occurred between sampling events. However, overwinter survival of immigrants to Eva Lake in 1962 (Armstrong 1965) was high ($\geq 94\%$). Thus, except for larger fish (especially fall spawners), we assume a similar low mortality rate. Again, if immigration was negligible and tagged and untagged fish died at similar rates, the abundance estimate is unbiased. Similarly, we do not know if significant emigration of Dolly Varden occurred between sampling events. Armstrong (1965, 1970) did not observe any fall/winter emigration at Eva Lake, but did observe moderate fall emigrations of smolt from a non-lake system (Hood Bay Creek). However, few smolts ($<10\%$ of all emigrants) emigrated from Hood Bay Creek after October. Since one tagged Dolly Varden was caught outside of Chilkat Lake prior to the second sampling event and reported to us, some emigration did occur between sampling events. There were no other reported recoveries despite a (sampled) sport fishery in Chilkat River prior to the observed emigration. Also, our weir was in operation 3 weeks prior to the first observed significant emigration of Dolly Varden (Figure 5). We thus think it unlikely that a significant emigration occurred between the fall and spring sampling events.

Another assumption required by the Peterson estimators is that all fish have the same probability of capture during the first sample or in the second sample or marked and unmarked fish mixed completely between the two samples. We met this assumption by stratifying the experiment by size groups, with each group having nearly homogeneous probabilities of recapture during the second sampling event.

Finally, the experiment requires that marked and unmarked fish experience the same mortality rate between sampling events, and that marked fish do not lose their marks. We observed substantial regeneration of the ventral fin hole punch on fish recaptured during the second event, but the punch mark was visible as a halo-shaped scar on the fin under close examination. Since we examined each captured fish ≥ 220 mm FL, we do not think we missed significant numbers of fish with 2 lost marks. Also, it is possible there was significant tagging-related mortality, but we did not observe any deaths during the fall tagging event, so tagging mortality is not an obvious source of bias in the experiment.

We were surprised to calculate that only $\approx 27\%$ of estimated overwintering abundance ≥ 230 mm FL was captured at the weir. While we clearly did not capture the entire emigration, fewer than 50% of the large (≥ 350 mm FL) Dolly Varden

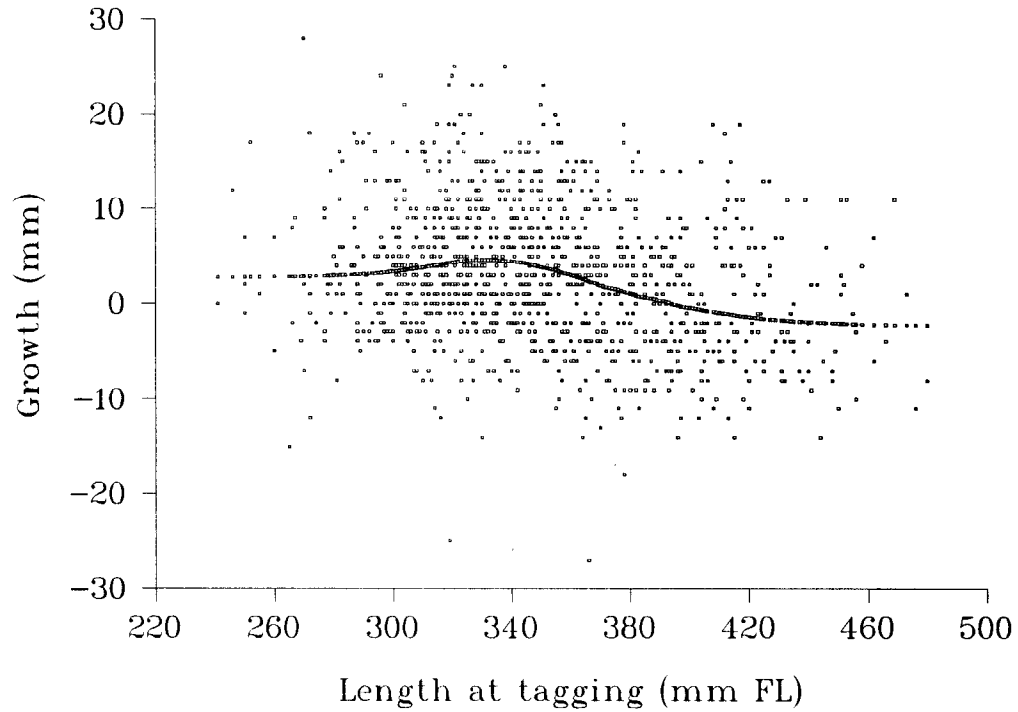


Figure 8. Scatterplot of the growth of 1,126 Dolly Varden tagged in fall 1989 and recaptured in spring 1990, after an average 201 (range 161-223) days at large. A nonparametric (LOWESS) trend line is drawn through the data; 36 observations outside the range $\bar{X} \pm 2$ SD are excluded from the scatterplot.

marked in the fall (576/1240, Table 2) were recaptured at the weir, in spite of the attempt to inspect nearly every spring emigrant ≥ 350 mm FL (Figure 5) for marks. However, Dolly Varden tagged in fall 1989 and not sampled at the weir did not generally die or lose their tags, because they were recovered relatively frequently in sport and commercial fisheries across northern Southeast Alaska (Appendix A). In fact, the two groups of tagged fish (those counted and those not counted at weir) were later reported to us at about the rates expected if mortality rates among groups were equal (Table 6). Thus, large numbers of Dolly Varden ≥ 230 mm FL either migrated out of Chilkat Lake prior to the spring emigration, evaded capture at the weir, or remained in Chilkat Lake after May 20. Since we did not observe large numbers of Dolly Varden evading the weir, we suspect a better understanding of the migratory dynamics of Dolly Varden using Chilkat Lake is required to solve the mystery raised in this experiment.

Researchers at Lake Eva believe that large Dolly Varden did not reside in Eva Lake between the spring emigration and the summer/fall immigrations of 1962 and 1963 (Robert Armstrong, Juneau, Alaska, personal communication). Based on data from creel surveys conducted during the cutthroat trout fishery in Chilkat Lake, about 200 Dolly Varden were harvested in Chilkat Lake during the summers of 1989 (Ericksen and Bingham 1990) and 1990 (unpublished data). Over 50% of these fish were caught during June and July, with harvest sampling (23 fish in June and 17 in July) indicating that fish of all sizes are present in the lake during the summer (Figure 9). We do not know to what extent these fish might be recent immigrants, or non-anadromous Dolly Varden.

The estimate of 151,773 (SE = 6,732) for overwintering abundance of Dolly Varden >230 mm FL is much greater than an estimate of 46,700 (SE = 17,300) Dolly Varden ≥ 267 mm FL resulting from 5 recaptures in 1989 (Ericksen et al. 1990). In making the former estimate, we used a curve-fitting procedure designed to remove recruitment (immigration) from the sample. If we had not done so, the estimate for Dolly Varden >200 mm FL ($n_1 = 1,813$; $n_2 = 292$; $m_2 = 5$) would be 88,583 (SE = 33,082), more like that obtained in this study.

Effort and harvests of Dolly Varden during the spring Chilkat River roadside fishery in 1990 (3,001 angler hours, 3,558 kept) were much higher than the effort and harvest estimated for 1989 (1,292 angler hours, 1,335 kept; Ericksen et al. 1990). This resulted partly from using only complete-trip interview data in 1990, and using both complete and incomplete interview data in 1989. To better compare the two years, the 1989 data was reanalyzed, using only complete-trip interview data.³ The resulting estimates for angler effort (1,596 angler hours, SE = 367) and harvests (2,276 kept, SE = 768) are less precise but more like those observed in 1990.

The contribution of tagged Dolly Varden to the spring fishery on the Chilkat River was much smaller than expected. However, this result is not surprising, since $<1\%$ of the catch occurred after April 15, when Dolly Varden emigrated from Chilkat Lake. The 1990 spring Dolly Varden fishery may thus have exploited a population which overwintered in the Chilkat River or in Mosquito Lake.

The contribution estimates we derived for selected sport fisheries are obviously biased low, relative to the total "exploitable" population using the lake. As

³ To complete an estimate for total effort and harvest, stratification for weekend and weekdays had to be dissolved. Also, only incomplete-trip interview data was available for the last biweekly period.

Table 6. Goodness-of-fit tests (H_0) comparing actual and expected numbers of (fall 1989) tagged Dolly Varden captured at the weir in 1990 and then recaptured in sport and commercial fisheries in Southeast Alaska.

Dolly Varden ≥ 230 mm FL			
	Recaptures ^a caught at the weir	Recaptures ^a not caught at the weir	
O_i = Observed Number	20	31	51
E_i = Expected Number ^b	15.7	35.3	51

H_0 : Recaptures^a of tagged fish occur in the same proportion as at the weir.

$$T = \sum (O_i - E_i)^2 / E_i = 1.72, \chi^2_{0.95,1} = 3.84; \text{ Result: Accept } H_0$$

Dolly Varden ≥ 350 mm FL			
	Recaptures ^a caught at the weir	Recaptures ^a not caught at the weir	
O_i = Observed Number	11	6	17
E_i = Expected Number ^b	7.9	9.1	17

H_0 : Recaptures^a of tagged fish occur in the same proportion as at the weir.

$$T = \sum (O_i - E_i)^2 / E_i = 2.28, \chi^2_{0.95,1} = 3.84; \text{ Result: Accept } H_0$$

^a Fish tagged in Chilkat Lake during fall 1989 and later sampled in sport and commercial fisheries.

^b Expected numbers n_{2j} equal the number of tagged Dolly Varden reported from sport and commercial fisheries times the proportion of the fall-tagged fish recaptured at the weir (0.307 above and 0.464 below).

^c The proportion of fish tagged in the fall which were captured at the weir, in each size group.

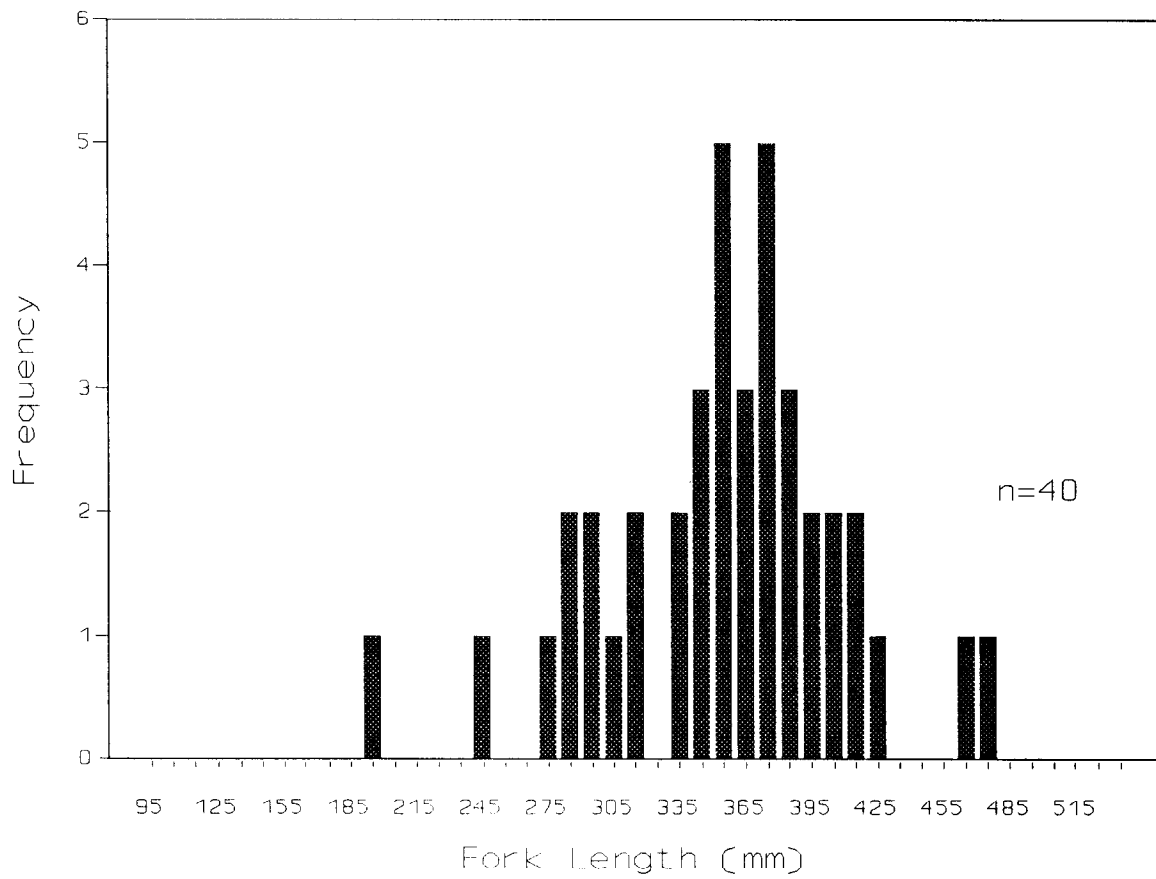


Figure 9. Length frequency of Dolly Varden sampled during creel surveys at Chilkat Lake during June and July 1989 and 1990. Fork lengths on the ordinate indicate the mid-point of 10-mm intervals.

previously mentioned, we marked only about half the Dolly Varden ≥ 350 mm FL overwintering in Chilkat Lake. Thus, the marking fraction (θ_h in equation 14) is closer to 0.5 than to 1.0, if reference is to the entire exploitable population in the lake, and our contribution estimates could therefore be roughly doubled. In addition, we marked only those fish ≥ 350 mm FL leaving Chilkat Lake. While nearly all Dolly Varden sampled for length in the spring Chilkat River and marine fisheries were ≥ 350 mm FL, 33%, 54%, and 40%, respectively, of those sampled in the Chilkoot River, Chilkat Lake, and northern Juneau roadside fisheries were < 350 mm FL. Thus, the contribution estimates for all "exploitable" fish are additionally low by similar factors.

Results from our tag returns indicate that once anadromous Dolly Varden wintering in Chilkat Lake leave fresh water, they scatter in all directions possible. However, Dolly Varden wintering in Chilkat Lake do not seem to be entering the Chilkoot River drainage in large numbers. The farthest documented recovery of a tagged Dolly Varden from Chilkat Lake was 202 km, farther than documented at Lake Eva (Armstrong 1965). However, Dolly Varden in northwestern Alaska have been reported as far as 1,540 km from their overwintering site (DeCicco 1990).

Based on present estimates, the density of Dolly Varden overwintering in Chilkat Lake in 1990 was about 154 Dolly Varden > 230 mm FL per hectare. This is much lower than the estimates for Salmon Lake in 1990 (815 Dolly Varden ≥ 190 mm FL per hectare: Schmidt and Marshall 1991), Buskin Lake in 1990 (893 Dolly Varden ≥ 210 mm FL per hectare: S. Sonnichsen, Alaska Department of Fish and Game, Anchorage, personal communication), or Lake Eva in 1963 (853 Dolly Varden of age classes IV-XI⁴: Armstrong 1965). Chilkat Lake has a surface area of 984 hectares; the other lakes are ≤ 100 hectares. The large size of Chilkat Lake implies it has relatively less littoral area per total surface than do smaller lakes. Also, numbers-per-hectare may not be a good measure of overwintering "capacity" for all lakes; Chilkat Lake could be below maximum carrying capacity for Dolly Varden.

The cause of the apparent decline in recreational harvest of Dolly Varden along the Chilkat River between 1986 and 1990 (Table 1) remains unclear. Although our results indicate that Dolly Varden overwintering in Chilkat Lake contributed little to the Chilkat River spring fishery in 1989 and in 1990, this may not be true in all years. It is likely that Dolly Varden emigrating from Chilkat Lake contribute more to the spring sport fishery in years when conditions allow the fishery to continue later into the spring, or cause fish to emigrate earlier. In fact, it is possible that the high harvests observed in 1985 and 1986 were a result of the "favorable" climatic conditions. However, we cannot ignore the possibility that a decline in Dolly Varden population is responsible for the declining harvest. Whatever the reasons for the pattern in the harvest data for Chilkat River, similar patterns are apparent in all Dolly Varden fisheries near Haines, Alaska during this period.

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⁴ 93,300 emigrants, of which 86,119, or 92.3%, are age IV-XI. The mean length of age IV Dolly Varden emigrants was ≈ 207 mm FL; see Heiser (1966).

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APPENDIX A

Appendix A1. Release and recovery information for Dolly Varden tagged in Chilkat Lake during fall 1989 and at Chilkat Lake outlet weir during spring 1990, and recovered sport and commercial fisheries, sorted by tagging event (year) and recovery date.

Tag number	Date tagged	Length at tagging	Date recovered	Days out	Length at recovery	Growth ^a	1989 tag recovered at weir?	Recovery location	Recovery source ^b
7375	15-Apr-90	466	17-Apr-90	2				20M Chilkat River	sport
7421	16-Apr-90	454	19-Apr-90	3				21M Chilkat River	sport
7842	21-Apr-90	384	22-Apr-90	1	384	0		24M Chilkat River	sport
7990	23-Apr-90	488	05-May-90	12				Breadline ^d	sport
8268	26-Apr-90	425	14-May-90	18				Point Sherman	sport
7385	15-Apr-90	425	19-May-90	34				Sunshine Cove ^d	sport
8311	27-Apr-90	398	26-May-90	29				Sunshine Cove ^d	sport
7352	15-Apr-90	418	28-May-90	43				Port Frederick ^g	sport
8069	25-Apr-90	382	09-Jun-90	45				Sunshine Cove ^d	sport
8991	03-May-90	436	14-Jun-90	42	445	9		Salmon River ^h	sport
8054	25-Apr-90	422	20-Jun-90	56				South Shelter ^d	sport
8545	29-Apr-90	444	19-Jul-90	81	457	13		Klukwan	subsistence
8753	05-May-90	438	19-Jul-90	75				Point Sherman	DGN
7585	17-Apr-90	411	28-Jul-90	102				Echo Cove ^d	sport
8776	06-May-90	407	13-Aug-90	99				Seduction Point	DGN
8771	05-May-90	356	16-Aug-90	103	381	25		Point Retreat ^d	sport
8274	26-Apr-90	355	23-Aug-90	119	390	35		8M Chilkat River	ADFG-FW
7693	18-Apr-90	381	28-Aug-90	132				Kelsall River	sport
8813	30-Apr-90	405	12-Sep-90	135	460	55		Little Salmon River	ADFG-S
8505	29-Apr-90	392	15-Sep-90	139	410	18		8M Chilkat River	ADFG-FW
8025	24-Apr-90	409	10-Oct-90	169				Assignment River	ADFG-S
8244	27-Apr-90	356	26-Oct-90	182				26M Chilkat River	ADFG-S
7725	18-Apr-90	376	07-Nov-90	203				20M Chilkat River	ADFG-S
7854	21-Apr-90	405	07-Nov-90	200				20M Chilkat River	ADFG-S
8166	26-Apr-90	409	18-Nov-90	206	445	36		Chilkat Lake	sport
8425	28-Apr-90	387	18-Feb-91	296				Klukwan	sport
7724	18-Apr-90	382	30-Mar-91	346				18M Chilkat River	sport
7576	17-Apr-90	413	03-Apr-91	351				Chilkat River	sport

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Appendix A1. (Page 2 of 4).

Tag number	Date tagged	Length at tagging	Date recovered	Days out	Length at recovery	Growth ^a	1989 tag recovered at weir?	Recovery location	Recovery source ^b
7935	23-Apr-90	399	06-Apr-91	348				7M Chilkat River	sport
8248	27-Apr-90	411	07-Apr-91	345				9M Chilkat River	sport
7927	23-Apr-90	387	07-Apr-91	349				9M Chilkat River	sport
8831	30-Apr-90	387	07-Apr-91	342				9M Chilkat River	sport
8384	28-Apr-90	354	28-Apr-91	365				Klukwan	sport
8461	29-Apr-90	402	23-May-91	389	430	28		8M Chilkat River	ADFG-FW
8210	27-Apr-90	395	25-Jun-91	424				Mab Island	DGN
7770	19-Apr-90	361	29-Jun-91	436	440	79		N. of Kensington	consultant
8462	29-Apr-90	400	14-Jul-91	441				8M Chilkat River	ADFG-FW
2591	12-Oct-89	311	11-Mar-90	150	313	2	i	Chilkat Lake	sport
7291	30-Oct-89	433	15-Mar-90	136	437	4	i	21M Chilkat River	sport
1572	10-Oct-89	405	18-Mar-90	159			i	Chilkat Lake	sport
6945	24-Oct-89	361	28-Apr-90	186	370	9	n	Mud Bay/Chilkoot	sport
5545	17-Oct-89	328	14-May-90	209			n	Berners Bay	sport
5500	17-Oct-89	334	19-May-90	214			Y	Sunshine Cove ^d	sport
5205	16-Oct-89	320	20-May-90	216			n	Chilkat Inlet	sport
7285	30-Oct-89	451	24-May-90	206			Y	Chilkat Inlet	sport
6348	19-Oct-89	323	28-May-90	221			n	Chilkoot Inlet	sport
7089	24-Oct-89	403	04-Jun-90	223			n	Portage Cove	sport
5811	18-Oct-89	306	15-Jun-90	240			n	Echo Cove ^d	sport
6897	23-Oct-89	414	18-Jun-90	238			Y	Eldred Rock	DGN
2101	11-Oct-89	343	26-Jun-90	258	355	12	n	Eldred Rock	DGN
7179	24-Oct-89	427	03-Jul-90	252			Y	MudBay/Chilkoot	DGN
6098	18-Oct-89	320	03-Jul-90	258	345	25	n	Chilkat Islands	DGN
6621	20-Oct-89	327	16-Jul-90	269			n	Chilkoot Inlet	DGN
6890	23-Oct-89	384	24-Jul-90	274	465	81	Y	Chilkat Inlet	sport
6005	18-Oct-89	265	01-Aug-90	287	295	30	n	Burro Creek ^f	PNP
6214	18-Oct-89	414	02-Aug-90	288	482	68	Y	12M Chilkat River	subsistence
5999	17-Oct-89	304	06-Aug-90	293			n	10M Chilkat River	sport
2833	13-Oct-89	299	10-Sep-90	332	325	26	n	9M Chilkat River	ADFG-FW

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Appendix A1. (Page 3 of 4).

Tag number	Date tagged	Length at tagging	Date recovered	Days out	Length at recovery	Growth ^a	1989 tag recovered at weir?	Recovery location	Recovery source ^b
5156	16-Oct-89	291	15-Sep-90	334	340	49	n	Chilkat Lake	sport
2573	12-Oct-89	393	01-Oct-90	354	420	27	Y	8M Chilkat River	ADFG-FW
1905	11-Oct-89	348	02-Oct-90	356	390	42	Y	8M Chilkat River	ADFG-FW
1405	10-Oct-89	320	11-Oct-90	366			Y	19M ^c Chilkat River	ADFG-S
2728	12-Oct-89	316	15-Oct-90	368			Y	24M Chilkat River	ADFG-S
2133	11-Oct-89	368	16-Oct-90	370			n	24M Chilkat River	ADFG-S
6097	18-Oct-89	320	16-Oct-90	363			Y	24M Chilkat River	ADFG-S
5322	16-Oct-89	331	16-Oct-90	365			n	24M Chilkat River	ADFG-S
6104	18-Oct-89	315	22-Oct-90	369			n	24M Chilkat River	ADFG-S
7238	26-Oct-89	340	22-Oct-90	361			n	24M Chilkat River	ADFG-S
6973	24-Oct-89	360	26-Oct-90	367			n	26M Chilkat River	ADFG-S
5959	18-Oct-89	291	26-Oct-90	373			Y	26M Chilkat River	ADFG-S
6964	24-Oct-89	450	08-Mar-91	500	533	83	n	20M Chilkat River	sport
6580	20-Oct-89	456	30-Mar-91	526			Y	18M Chilkat River	sport
6598	20-Oct-89	343	01-Apr-91	528			n	24M Chilkat River	sport
5148	16-Oct-89	325	01-Apr-91	532			Y	24M Chilkat River	sport
6751	23-Oct-89	395	03-Apr-91	527			Y	Chilkat River	sport
1512	10-Oct-89	349	05-Apr-91	542			Y	8M Chilkat River	sport
5620	17-Oct-89	342	08-Apr-91	538			n	9M Chilkat River	sport
2067	11-Oct-89	304	12-Apr-91	548			n	23M Chilkat River	sport
6546	20-Oct-89	366	24-Apr-91	551			n	Wells Bridge	sport
6844	23-Oct-89	385	11-May-91	565			Y	MudBay/Chilkoot	sport
5991	17-Oct-89	319	02-Jun-91	593	406	87	n	Portage Cove	sport
2565	12-Oct-89	400	06-Jun-91	602	401	1	Y	False Pt Retreat ^d	sport
1623	10-Oct-89	277	06-Jul-91	634	370	93	n	8M Chilkat River	ADFG-FW
6165	18-Oct-89	422	06-Jul-91	626			Y	8M Chilkat River	ADFG-FW
2449	12-Oct-89	270	07-Jul-91	633			Y	9M Chilkat River	ADFG-FW
5638	17-Oct-89	331	11-Jul-91	632			n	8M Chilkat River	ADFG-FW
7082	24-Oct-89	334	12-Jul-91	626			n	8M Chilkat River	ADFG-FW
5662	17-Oct-89	330	13-Jul-91	634			n	Chilkat State Park	sport

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Appendix A1. (Page 4 of 4).

Tag number	Date tagged	Length at tagging	Date recovered	Days out	Length at recovery	Growth ^a	1989 tag recovered at weir?	Recovery location	Recovery source ^b
5758	17-Oct-89	334	15-Jul-91	636	415	81	n	8M Chilkat River	ADFG-FW
2122	11-Oct-89	321	16-Jul-91	643	410	89	n	8M Chilkat River	ADFG-FW
5327	16-Oct-89	313	19-Jul-91	641	400	87	n	8M Chilkat River	ADFG-FW
3518	11-Oct-88	363	09-Sep-90	698				Antler River ^e	sport

^a Difference between lengths at recovery and release in mm.

^b sport = sport catch.

ADFG-S = Ak. Dept. of Fish & Game project: seining for marked coho and chum salmon.

ADFG-FW = Ak. Dept. of Fish & Game project: fish wheel sampling on the Chilkat River.

DGN = commercial drift gill net fishery.

PNP = private non-profit hatchery.

subsistence = subsistence set net fishery.

consultant = consultant working for Echo Bay Exploration.

^c Number indicates approximate mile marker of Haines Highway adjacent to recovery location.

^d Juneau area.

^e Tributary of the Berners River.

^f Skagway area.

^g Hoonah area.

^h Gustavus area.

ⁱ Captured prior to the emigration.

Appendix A2. Number aged (N), mean fork length, and mean weight of Dolly Varden mortalities sampled at Chilkat Lake outlet weir, by age and sex, April 15 through May 20, 1990.

Otolith	Length			Weight		
Age	N	Mean	SE	N	Mean	SE
MALES						
4	2	218	6	2	75	25
5	5	249	13	5	136	25
6	3	299	15	3	210	10
7	3	309	7	3	223	23
8	2	411	9	2	545	35
FEMALES						
3	1	174		1	40	
4	1	210		1	70	
5	3	242	6	3	110	6
6	4	309	8	4	278	40
7	4	362	15	4	380	48
8	2	408	18	2	465	25
COMBINED ^a						
3	1	174		1	40	
4	3	215	4	3	73	15
5	10	250	7	10	129	15
6	13	313	5	13	278	19
7	18	359	8	18	383	25
8	17	398	5	17	491	22
9	3	447	3	3	680	68

^a Males, females, and unsexed fish.

Appendix A3. Number aged (N), mean fork length, and mean weight of Dolly Varden sampled from harvests in the fishery for Dolly Varden along the Chilkat River, by age and sex, March 26 through April 29, 1990.

Otolith	Length			Weight		
Age	N	Mean	SE	N	Mean	SE
MALES						
6	1	452		1	750	
7	8	439	14	7	661	66
8	11	471	6	8	916	50
9	3	498	25	2	1,013	338
10	1	561				
FEMALES						
6	5	376	18	4	375	32
7	13	421	8	12	596	33
8	13	438	7	8	622	52
9	2	444	14	2	725	25
11	1	516		1	1,450	
COMBINED ^a						
6	6	388	19	5	450	79
7	21	428	7	19	620	32
8	24	453	6	16	769	51
9	5	476	20	4	869	161
10	1	561				
11	1	516				

^a Males, females, and unsexed fish.

Appendix A4. Number aged (N), mean fork length, and mean weight of Dolly Varden sampled from harvests in the fishery for cutthroat trout on Chilkat Lake, by age and sex, May 21 through October 7, 1990.

Otolith Age	Length			Weight		
	N	Mean	SE	N	Mean	SE
MALES						
5	2	273	3	2	175	25
6	5	318	10	5	329	41
7	7	369	7	7	472	30
8	3	403	10	3	533	73
FEMALES						
5	5	261	19	5	176	9
6	2	311	11	2	273	33
7	5	366	6	5	514	46
8	1	375		1	480	
9	1	460		1	1,100	
COMBINED ^a						
5	7	264	13	7	176	8
6	7	316	8	7	313	31
7	12	368	5	12	490	25
8	4	396	10	4	520	53
9	1	460		1	1,100	

^a Males, females, and unsexed fish.

Appendix A5. Number aged (N), mean fork length, and mean weight of Dolly Varden sampled in harvests from the fishery for Dolly Varden and other species on the Chilkoot River, by age and sex, June 25 through November 4, 1990.

Otolith	Length			Weight		
Age	N	Mean	SE	N	Mean	SE
MALES						
4	2	252	4	2	175	15
5	6	302	10	6	297	29
6	13	337	7	13	404	27
7	16	385	8	16	573	43
8	9	429	8	9	826	72
9	4	458	9	4	1,048	91
11	1	515		1	1,450	
FEMALES						
5	7	298	13	7	264	29
6	15	342	6	15	426	21
7	21	374	5	21	561	31
8	8	427	9	8	824	66
9	2	474	9	2	1,250	50
COMBINED ^a						
4	2	252	4	2	175	15
5	13	300	8	13	279	20
6	28	340	5	28	416	17
7	37	379	5	37	566	25
8	17	428	6	17	825	48
9	6	463	7	6	1,115	73
11	1	515		1	1,450	

^a Males, females, and unsexed fish.

